Ensemble of Sea Ice Initial Conditions for Interannual Climate Predictions

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A – Sea Ice Predictability

- **Sea ice area persistence 2-5 months**
- **Re-emergence up the 15 months (Blanchard-Wrigglesworth et al, 2011) : summer-to-summer (memory in the thickness), winter-to-spring (memory in the SST)**
- **Summer Arctic sea ice thickness precursor of winter sea ice extent (Chevallier and Salas-Melia, 2012)**

→ Potential for interannual sea ice predictions if sea ice volume properly initialized

B – Issue : Observational coverage

- **Before 1973 :**
  - **Arctic : monthly sea ice extent estimates**
  - **Antarctic : climatologies 1929-1937 & 1947-1962**
- **From 1973 : quasi weekly estimates of sea ice concentration, US Navy, Canadian, Danish aerial reconnaissance**
- **From 1978 : 2-day frequency later daily, gridded, 1°, satellite microwave imagery**
- **First sea ice thickness dataset in 2010 : submarine, ULS**

→ Need for sea ice reconstruction for 1960-present (CMIP5 target for prediction exercise)

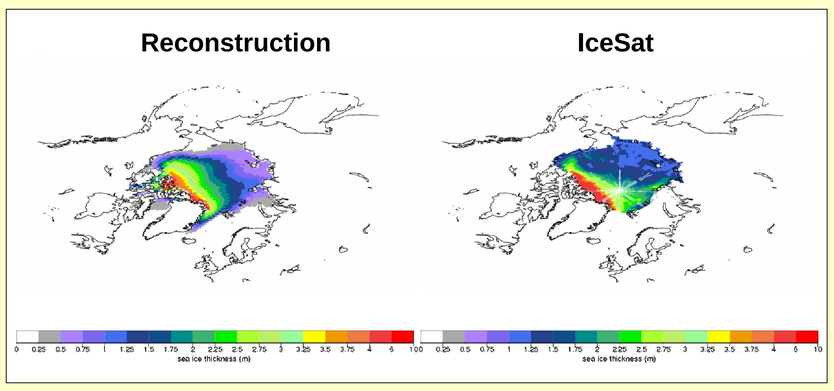
C – Sea Ice Reconstructions

- **NEMO3.2 ocean model + LIM2 sea ice model**
- **Forcings : 1958-2006 DFS4.3 or 1979-2010 ERA-interim**
- **Nudging : T and S toward ORAS4, timescales = 360 days below 800m, and 10 days above except in the mixed layer, except at the equator (1°S-1°N), SST & SSS restoring (-40W/m2, -150 mm/day/psu)**
- **Wind perturbations + 5-member ORAS4 - - - > 5 members for sea ice reconstruction**

→ 5-member sea ice reconstruction for 1958-2012

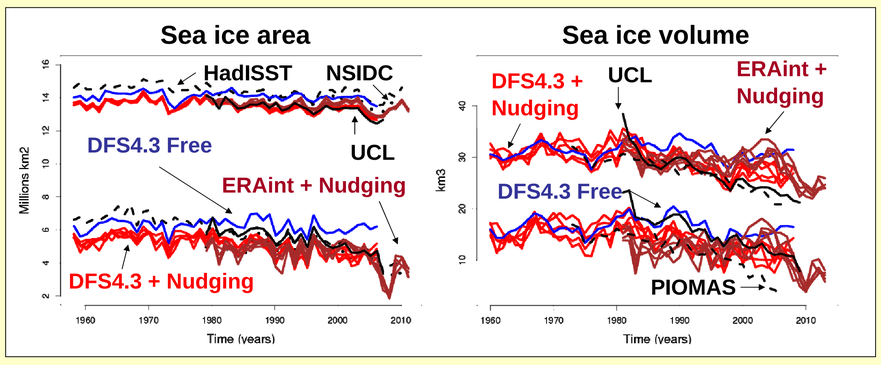
D – Validation of the 5-member sea ice reconstruction

October-November Arctic sea thickness



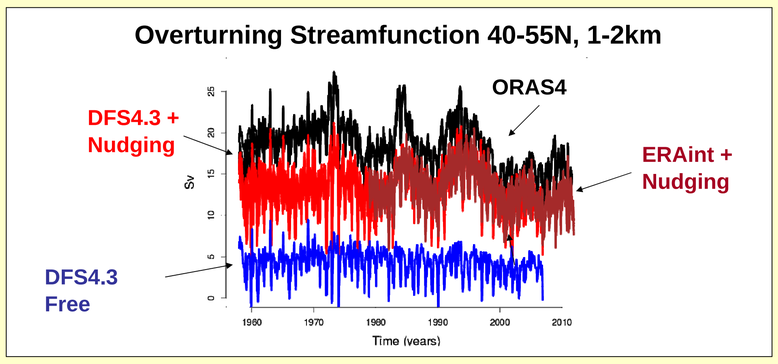
→ Too much ice in central Arctic, too few the Chucki and East Siberian Seas

March and September Arctic sea ice



→ Bias but reasonable agreement of interannual variability

Atlantic Meridional Overturning Circulation



→ Ocean nudging allows capturing decadal variabiltiy in AMOC and warm inflow in the Barents Sea

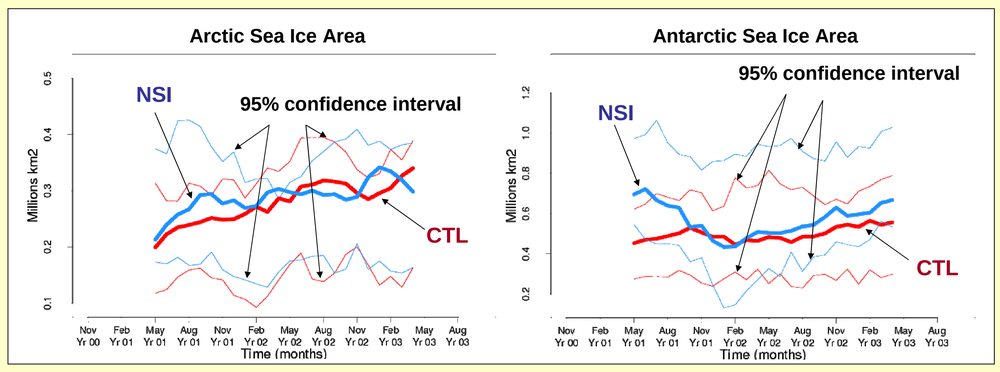
E – Climate Predictions

- **Ec-Earth 2.3 ocean-atmosphere coupled climate model**
- **Initialization every 2 years from 1960 to 2004 + 1965 + 1975 + 1985 + 1995 + 2005 on 1 November = 28 forecasts**
- **Ocean from ORAS4, Atmosphere from ERA40/ERAInt, Sea ice from our 5-member reconstruction, full-field initialization**
- **Sensitivity experiment with New Sea Ice initial conditions = NSI is compared to previous CMIP5 contribution = CTL initialized from a NEMO2-LIM2 simulation forced by DFS4.3**

→ Assessment of the benefits from using our new sea ice initial conditions by comparing NSI to CTL

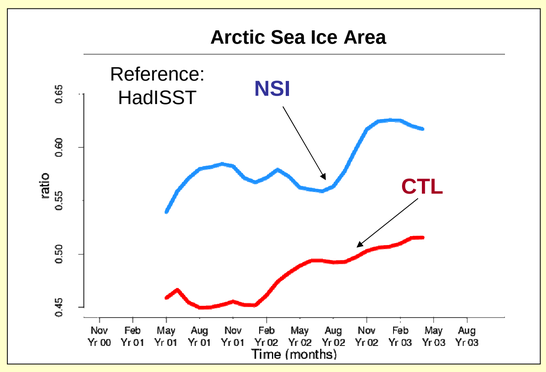
D – Spread between the forecast members

Interquartile Range of the ensemble members around the ensemble-mean



→ Larger spread between members for sea ice variables

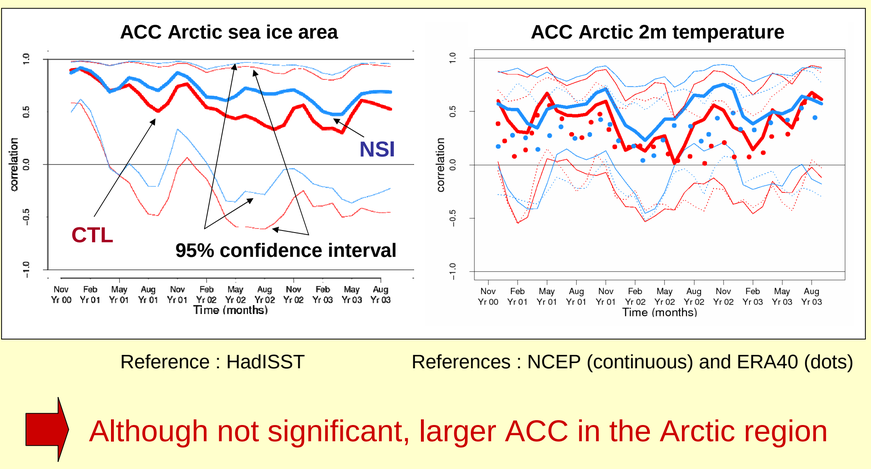
Ratio SD (members) / RMSE (ensemble-mean)



→ Spread closer to RMSE

E – Forecast quality

Improved forecast skill in the Arctic



Reference : HadISST

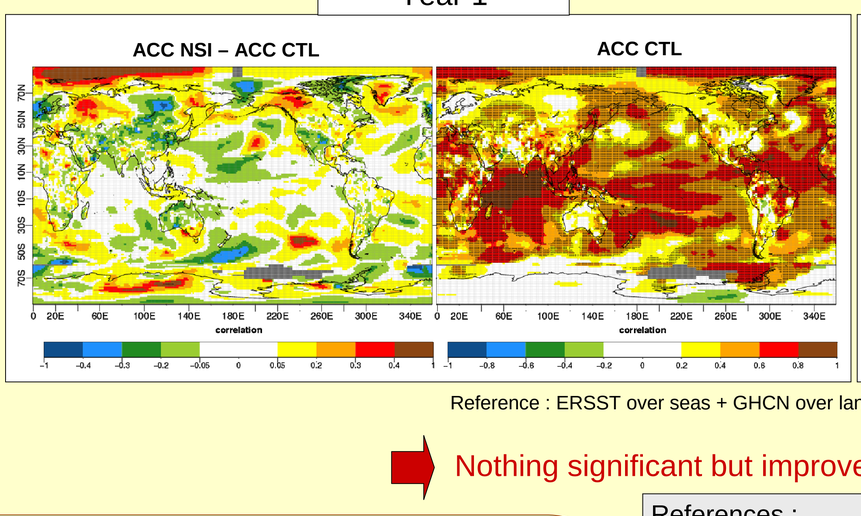
References : NCEP (continuous) and ERA40 (dots)

→ Although not significant, larger ACC in the Arctic region

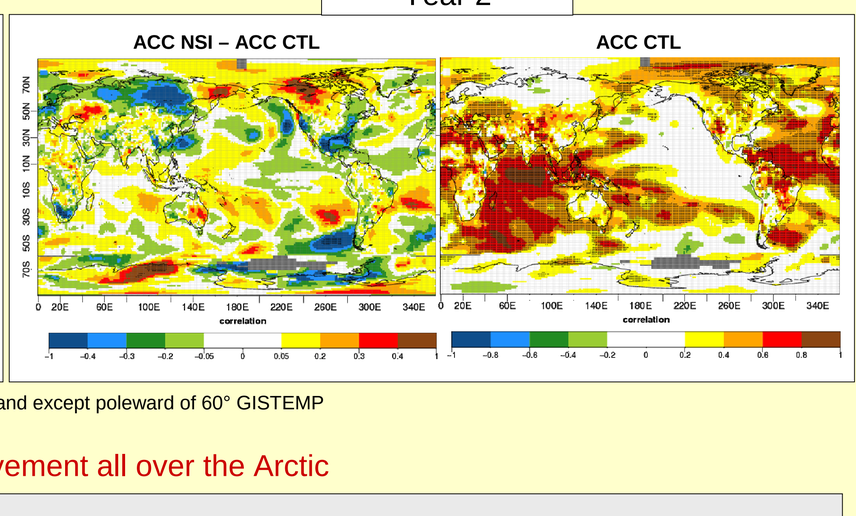
Improvement confined to the Arctic

2m temperature

Year 1



Year 2



Reference : ERSST over seas + GHCN over land except poleward of 60° GISTEMP

→ Nothing significant but improvement all over the Arctic

Conclusions

5-member Sea Ice Reconstruction:

- **Too much sea ice in the central Arctic, too few in the Chucki and East Siberian Seas**
- **Reasonable agreement of the Arctic sea ice interannual variability with NSIDC and HadISST**

Climate predictions initialized from this 5-member reconstruction:

- **The spread between members is larger for sea ice variables, thus more representative of the forecast error**
- **Although the differences are not significant, the ACC is increased for Arctic sea ice area and 2m temperature**
- **The increase in ACC for 2m temperature is confined to the Arctic**

References :

Guemas V., Doblas-Reyes F., Mogensen K., Tang Y., Keeley S., 2013, Ensemble of sea ice initial conditions for interannual climate predictions, submitted to Climate Dynamics.

Chevallier M., Salas-Mélia D., 2011, The role of sea ice thickness distribution in the arctic sea ice potential predictability: a diagnostic approach with a coupled GCM. J Clim 25:3025–3038, DOI 10.1175/JCLI-D-11-00209.1.

Blanchard-Wrigglesworth E., Armour K.C., Bitz C.M., DeWeaver E., 2011a, Persistence and Inherent Predictability of Arctic Sea Ice in a GCM Ensemble and Observations. J Clim 24:231–250.

Blanchard-Wrigglesworth E., Bitz C.M., Holland M.M., 2011b, Influence of initial conditions and climate forcing on predicting Arctic sea ice. Geophys. Res. Let. 38(L18503), DOI 10.1029/2011GL048807.